Three-color photograph transmitted over telephone line, as three separate black and white records, each corresponding to one primary color

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The Transmission of Pictures Over Telephone Lines

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Introduction

THE problem of directly transmitting drawings, figures and photographs from one point to another by means of electricity has long attracted the attention and curiosity of scientists and engineers.[1] The broad principles of picture transmission have been recognized for many years. Their reduction to successful practice, however, required, among other things, the perfection of methods for the faithful transmission of electrical signals to long distances, and the development of special apparatus and methods which have become a part of the communication art only within the last few years. Prominent among the newer developments which have facilitated picture transmission are the photoelectric cell, the vacuum tube amplifier, electrical filters, and the use of carrier currents.

None of the systems heretofore devised have been sufficiently developed to meet the requirements of modern commercial service. The picture transmission system described in this article has been designed for practical use over long distances, employing facilities of the kind made available by the network of the Bell System.

The desirability of adding picture transmission facilities to the other communication facilities offered by the Bell System seems now to be well assured. Various engineers of the System have made suggestions and carried out fundamental studies of the possibilities for picture transmission offered by the telephone and telegraph facilities in the Bell System Plant which have aided materially in the development of the method to be described.

[1] A comprehensive account of earlier work in Picture Transmission will be found in "Telegraphic Transmission of Pictures," T. Thorne Baker, Van Nostrand, 1910, and the "Handbuch der Phototelegraphie und Telautographie," Korn and Glatzel, Leipzig, Nemnich, 1911.

The account of the picture transmission system which follows is intended to give only a general idea of the work as a whole. A number of engineers have collaborated in this work, and it is expected that later publications will describe various features of the system and its operation in greater detail.

General Scheme of Picture Transmission

Reduced to its simplest terms, the problem of transmitting a picture electrically from one point to another calls for three essential elements: The first is some means for translating the lights and shades of the picture into some characteristic of an electric current;

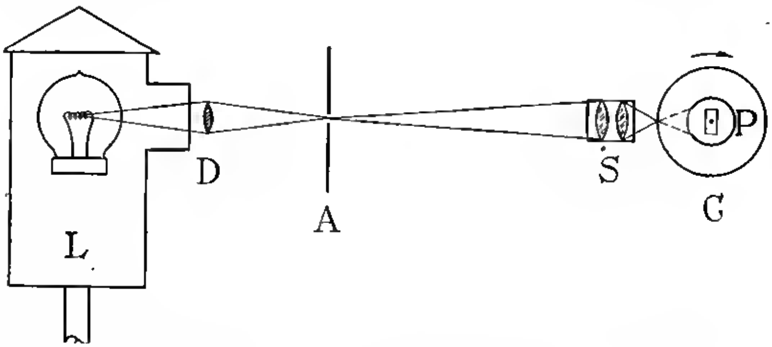

Fig. 1—Sending end optical system in section: (L) light source; (D) condensing lens; (A) diaphragm; (S) projection lens; (C) transparent picture film in cylindrical form; (P) photoelectric cell

the second is an electrical transmission channel capable of transmitting the characteristic of the electric current faithfully to the required distance; the third is a means for retranslating the electrical signal as received into lights and shades, corresponding in relative values and positions with those of the original picture.

Analyzed for purposes of electrical transmission, a picture consists of a large number of small elements, each of substantially uniform brightness. The transmission of an entire picture necessitates some method of traversing or scanning these elements. The method used in the present apparatus is to prepare the picture as a film transparency which is bent into the form of a cylinder. The cylinder is then mounted on a carriage, which is moved along its axis by means of a screw, at the same time that the film cylinder is rotated. A small spot of light thrown upon the film is thus caused to traverse the entire film area in a long spiral. The light passing into the

interior of the cylinder then varies in intensity with the transmission or tone value of the picture. The optical arrangement by which a small spot of light is projected upon the photographic transparency is shown in section in Fig. 1.

The task of transforming this light of varying intensity into a variable electric current is performed by means of an alkali metal

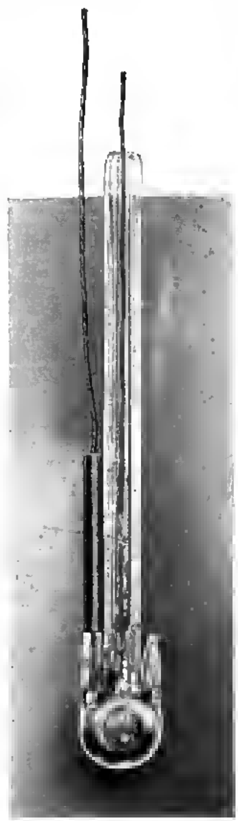

Fig. 2—Photograph of photoelectric cell of type used in picture transmission

photoelectric cell. This device, which is based on the fundamental discovery of the photoelectric effect by Hertz, was developed to a high degree of perfection by Elster and Geitel. It consists of a vacuum tube in which the cathode is an alkali metal, such as potassium. Under illumination, the alkali metal gives off electrons, so that when the two electrodes are connected through an external circuit, a current flows. This current is directly proportional to the intensity

of the illumination, and the response to variations of illumination is practically instantaneous. A photograph of a photoelectric cell of the type used in the picture transmission apparatus is shown in Fig. 2. This cell is placed inside the cylinder formed by the photographic transparency which is to be transmitted, as shown in Fig. 1. As the film cylinder is rotated and advanced, the illumination of the cell and consequently the current from it registers in succession the brightness of each elementary area of the picture.

Assuming for the moment that the photoelectric current, which is a direct current of varying intensity, is of adequate strength for successful transmission, and that the transmission line is suitable for

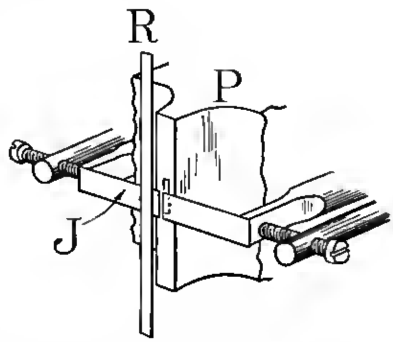

Fig. 3—Light valve details: (R) ribbon carrying picture current; (P) pole piece of magnet; (J) jaws of aperture behind ribbon

carrying direct current, we may imagine the current from the photoelectric cell to traverse a communication line to some distant point. At the distant point it is necessary to have the third element above mentioned, a device for retranslating the electric current into light and shade. This is accomplished in the present system by a device, due in its general form to Mr. E. C. Wente, termed a "light valve." This consists essentially of a narrow ribbon-like conductor lying in a magnetic field in such a position as to entirely cover a small aperture. The incoming current passes through this ribbon, which is in consequence deflected to one side by the inter-action of the current with the magnetic field, thus exposing the aperture beneath. Light passing through this aperture is thus varied in intensity. If it then falls upon a photographic sensitive film bent into cylindrical form, and rotating in exact synchronism with the film at the sending end, the film will be exposed by amounts varying in proportion to the lights and shades of the original picture. The ribbon and aperture of the light valve are shown diagrammatically in Fig. 3. Fig. 4

shows a section of the receiving end of a system of the sort postulated, with its light source, the light valve, and the receiving cylinder.

Adaptation of Scheme to Telephone Line Transmission

The simple scheme of picture transmission just outlined must be modified in order to adapt it for use on commercial electrical communication systems, which have been developed primarily for other purposes than picture transmission. Of existing electrical means of communication, which include land wire systems (telegraph and telephone), submarine cable, and radio, the wire system, as developed

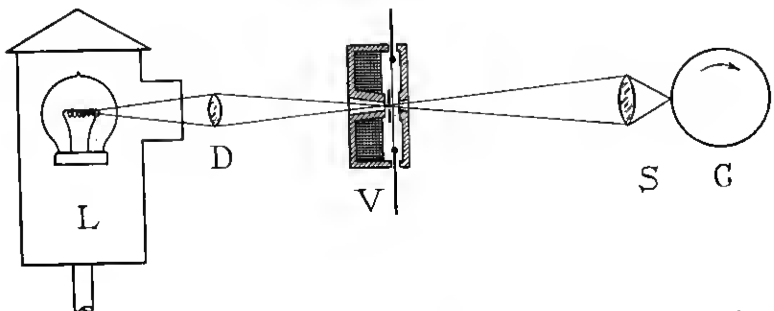

Fig. 4—Section of receiving end optical system: (L) light source; (D) condensing lens; (V) light valve; (S) projection lens; (C) sensitive film

for the telephone, offers great advantage when all factors are considered, including constancy, freedom from interference and speed. The picture transmission system has accordingly been adapted to it.

In the simple scheme of picture transmission outlined in the preceding section, the photoelectric cell gives rise to a direct current of varying amplitude. The range of frequency components in this current runs from zero up to a few hundred cycles. Commercial long distance telephone circuits are not ordinarily arranged to transmit direct or very low frequency currents, so the photoelectric currents are not directly transmitted. Moreover, these currents are very weak in comparison with ordinary telephone currents. On account of these facts, the current from the photoelectric cell is first amplified by means of vacuum tube amplifiers [2] and then is impressed upon a vacuum tube modulator jointly with a carrier current whose frequency is about 1,300 cycles per second. What is transmitted over

[2] For a very full description of the standard telephone repeater the reader is referred to "Telephone Repeaters," Gherardi and Jewett, Trans. A. I. E. E., Nov., 1919, Vol. 38, part 2, pp. 1287–1345.

Fig. 5—Portion of transmitted picture of variable width line type, enlarged

the telephone line is, then, the carrier wave [3] modulated by the photoelectric wave so that the currents, in frequency range and in amplitude, are similar to the currents corresponding to ordinary speech.

When the carrier current, modulated according to the lights and shades of the picture at the sending end, traverses the ribbon of the light valve at the receiving end, the aperture is opened and closed with each pulse of alternating current. The envelope of these pulses follows the light and shade of the picture, but the actual course of

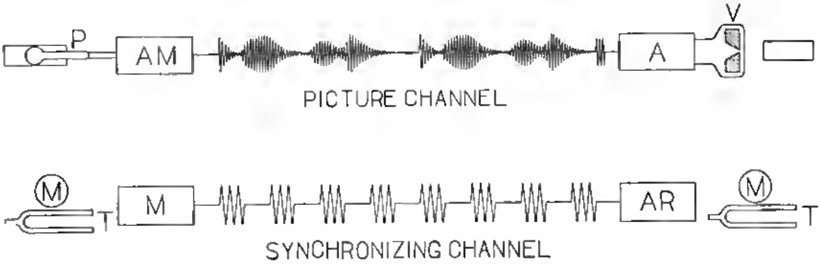

Fig. 6—Diagrammatic representation of the picture and synchronizing currents. (P) photoelectric cell; (AM) amplifier modulator; (A) amplifier; (V) light valve; (M) phonic wheel motors; (T) tuning forks; (AR) amplifier rectifier

the illumination with time shows a fine structure, of the periodicity of the carrier. This is shown by the enlarged section of a picture, Fig. 5; in this the black lines are traces of the image of the light valve aperture. Superposed on the larger variations of width, which are proportional to the light and shade of the picture, small steps will be noted (particularly where the line width varies rapidly); these are caused by the carrier pulses.

Synchronization

In order that the light and shade traced out on the receiving cylinder shall produce an accurate copy of the original picture, it is necessary that the two cylinders rotate at the same uniform rate. This, in general, demands the use of accurate timing devices. The means employed in the present apparatus consist of phonic wheels or impulse motors controlled by electrically operated tuning forks.[4] Were it

[3] A description of electrical communication by means of carrier currents will be found in "Carrier Current Telephony and Telegraphy," Colpitts and Blackwell, Trans. A. I. E. E., 1921, Vol. 40, pp. 205–300. A discussion of the relations between the several components of the signal wave employed in carrier is given in "Carrier and Sidebands in Radio Transmission," Hartley, Proc. I. R. E., Feb., 1923, Vol. 11, No. 1, pp. 34–55.

[4] A detailed description of the construction and operation of the impulse motor and its driving fork is given in "Printing Telegraph Systems," Bell Trans. A. I. E. E., 1920, Vol. 39, Part 1, pp. 167–230.

possible to have two forks at widely separated points running at exactly the same speed, the problem of synchronizing would be immediately solved. Actually this is not practical, since variations of speed with temperature and other causes prevent the two forks from operating closely enough together for this purpose. If the two cylinders are operated on separate forks, even though each end of the apparatus runs at a uniform rate, the received picture will, in general, be skewed with respect to the original. The method by which this difficulty has been overcome in the present instance is due to Mr. M. B. Long. Fundamentally the problem is solved by controlling the phonic wheel motors at each end by the same fork. For this purpose it has been found desirable to transmit to the receiving station impulses controlled by the fork at the sending end. The problem of transmitting both the fork impulses and the picture current simultaneously could be solved by the use of two separate circuits. If this were done the currents going over the two lines would be substantially as shown in Fig. 6, where the upper curve represents the modulated picture carrier for two successive revolutions of the picture cylinder, and the lower curve shows the synchronizing carrier current modulated by the fork impulses.

It would not, however, be economical to use two separate circuits for the picture and synchronizing channels, consequently the two currents are sent on the same circuit. In order to accomplish this, the picture is sent on the higher frequency carrier, approximately 1,300 cycles per second, and the synchronizing pulses are sent on the lower frequency carrier, approximately 400 cycles per second, both lying in the range of frequencies readily transmitted by any telephone circuit. These carrier frequencies are obtained from two vacuum tube oscillators.[5] The two currents are kept separate from each other by a system of electrical filters at the sending and receiving ends, so that while the current on the line consists of a mixture of two modulated frequencies, the appropriate parts of the receiving apparatus receive only one carrier frequency each.[6]

[5] The vacuum tube oscillator as a source of carrier current is described in Colpitts and Blackwell, *Loc. Cit.* A general discussion of the vacuum tube oscillator is given in the "Audion Oscillator," Heising, *Jour. A. I. E. E.* April and May, 1920. A discussion of the arrangement of the particular oscillator used with the picture transmission equipment is given in "Vacuum Tube Oscillator," Horton, *Bell System Tech. Jour.* July, 1924, Vol. 3, No. 3, pp. 508–524.

[6] The application of wave filters to multi-channel communication systems is discussed in Colpitts and Blackwell, *Loc. Cit.* More complete discussions are to be found in: "Physical Theory of Electric Wave Filters," Campbell, *Bell System Tech. Jour.* Nov., 1922, Vol. 1, No. 2, pp. 1–32.

Description of Apparatus

Mechanical Arrangements

The essential parts of the mechanism used for rotating and advancing the cylinder at the sending station, and for holding the photoelectric cell and the amplifying and modulating system are shown in the photograph, Fig. 7. At the extreme left is the phonic wheel impulse motor, which drives the lead screw through a spiral gear.

Fig. 7—Sending end apparatus showing motor, film carriage, optical system and amplifier modulator

The spiral gear ordinarily turns free of the lead screw, but may be engaged with it by a spring clutch. The lamp housing, which provides the illumination for the photoelectric cell, is in the foreground at the center of the photograph. The photoelectric cell is in a cylindrical case at the left end of the large box shown on the track and projects into the picture cylinder on which a film is in process of being clamped. The amplifier and modulator system is carried in the large box to the right, which is mounted on cushion supports to eliminate disturbances due to vibration.

The receiving end mechanism for turning and advancing the cylinder is similar to that at the sending end. The parts peculiar to the receiving end are shown in Fig. 8. They consist of the light valve, which is in the middle of the photograph, and the lens for projecting the light from it upon the cylinder. The metal cylinder

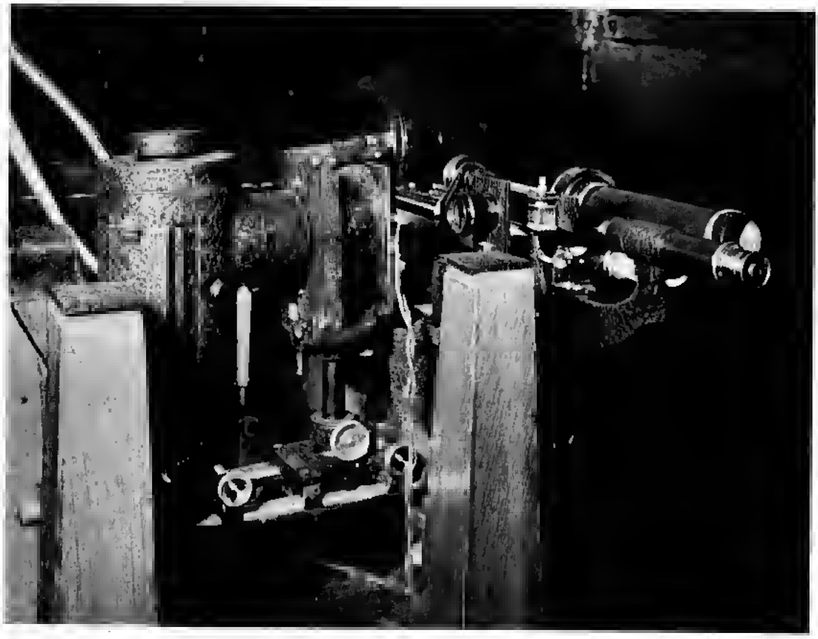

Fig. 8—View of receiving end apparatus showing light valve and observation microscope

around which the sensitive photographic film is wrapped, appears at the extreme right. The microscope and prism shown are used for inspecting the light valve aperture for adjusting purposes.

Electrical Circuits

The essential parts of the electrical circuits used are shown in the schematic diagrams, Figs. 9 and 10, in which the various elements which have been described previously are shown in their relations to each other.

Certain portions of the electrical circuits deserve somewhat detailed treatment. One of these is the amplifier-modulator system for the picture channel, the other is the filter system employed for separating the picture and synchronizing channels.

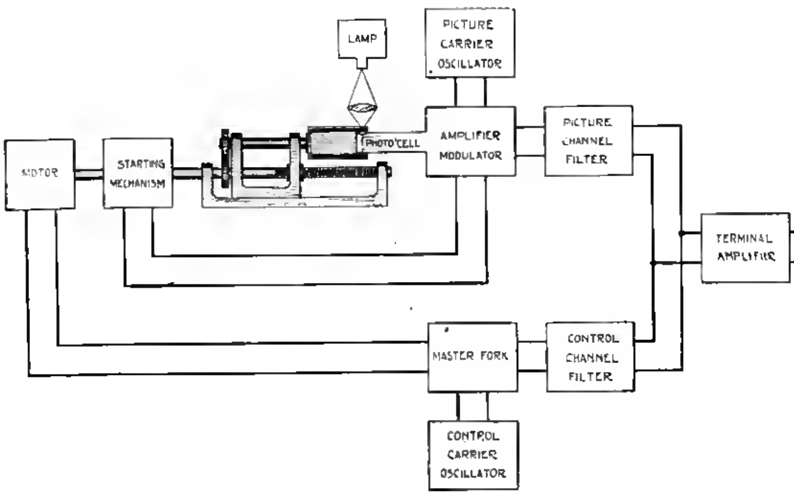

Fig. 9—Schematic diagram of sending end apparatus

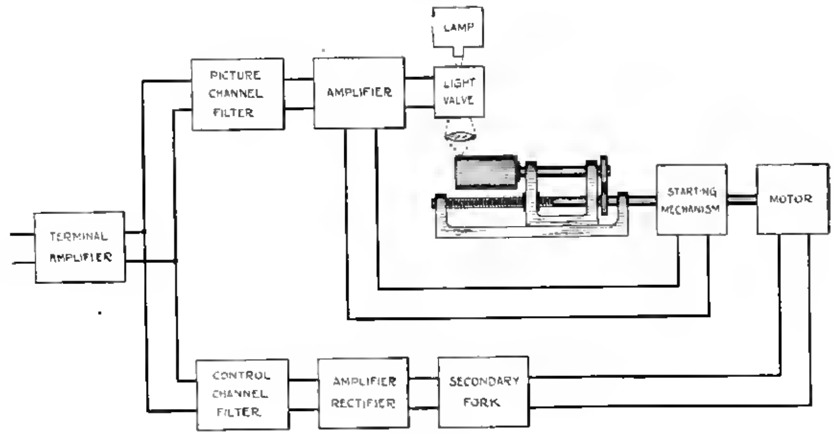

Fig. 10—Schematic diagram of receiving end apparatus

In Fig. 11 is shown (at the top) a diagram of the direct current amplifier and the modulator used for the picture channel, together with diagrams (at the bottom) showing the electrical characteristics of each element of the system. Starting at the extreme left is the

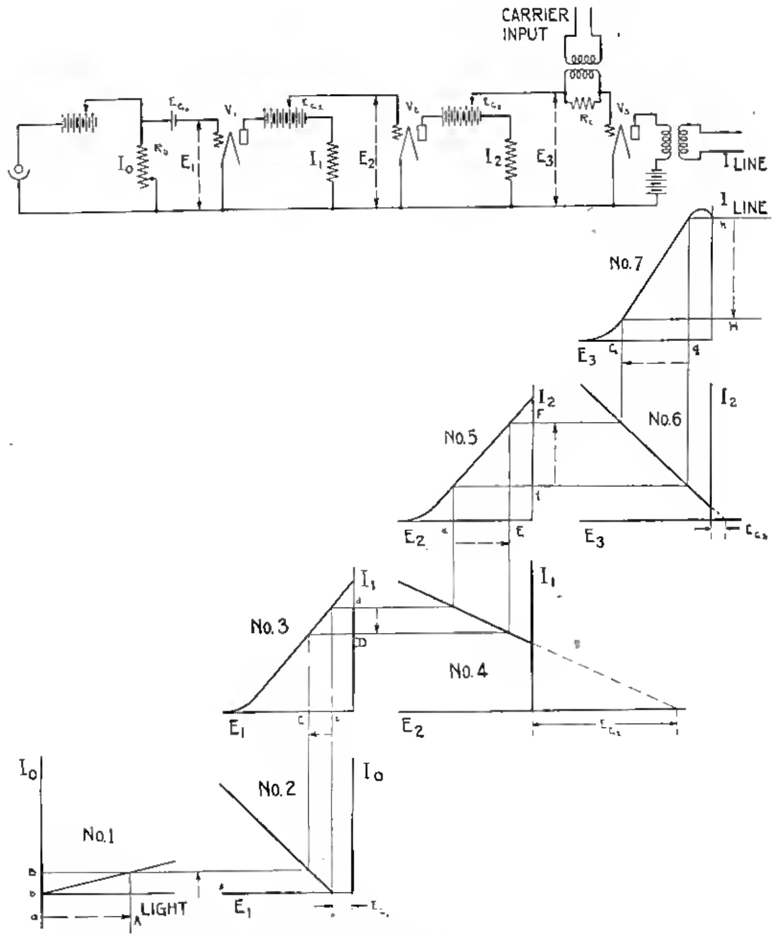

Fig. 11—Circuit schematic of amplifier-modulator with characteristics of each element

photoelectric cell, the current from which passes through a high resistance. The potential tapped off this resistance (of the order of 30 or 40 millivolts) is applied to the grid of the first vacuum tube amplifier. The second vacuum tube amplifier is similarly coupled

with the first, and the vacuum tube modulator in turn to it. The relationship between illumination and current in the photoelectric cell is, as shown in diagram No. 1, linear from the lowest to the highest values of illumination. The voltage-current (E versus I) character-

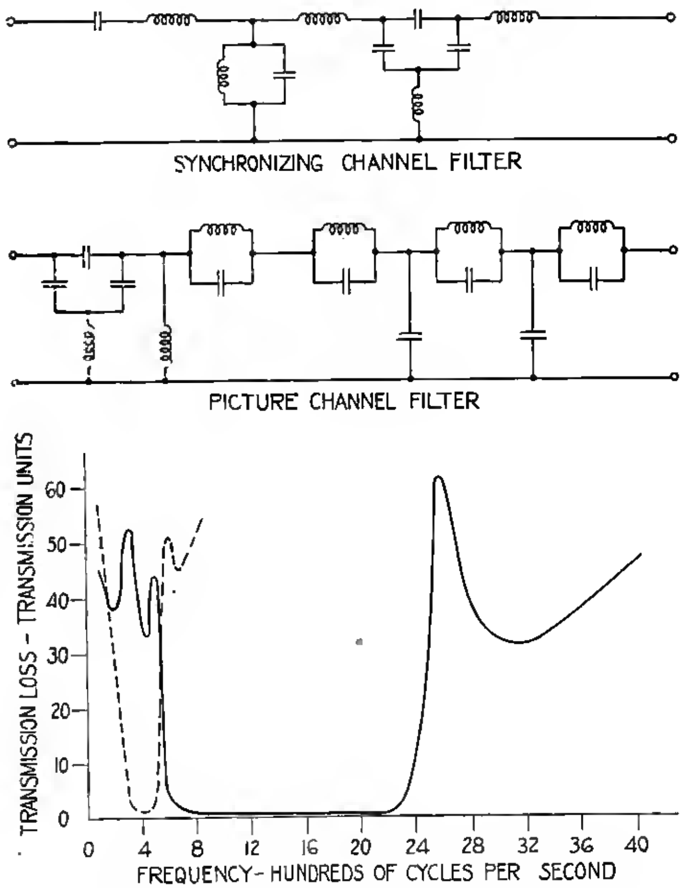

Fig. 12—Circuit schematics (above) and attenuation characteristics (below) of picture (full line) and synchronizing (dashed line) channel filters

istics of the amplifying tubes and the modulating tube circuits are shown in the figure by the diagrams which lie immediately below these tubes. They are not linear over their whole extent. It becomes necessary, therefore, in order to preserve the linear characteristic, which is essential for faithful picture transmission, to locate the range of variation of current in each of the latter tubes on a linear

portion of their characteristics. This is accomplished by appropriate biasing voltages (Eg), as shown. As a consequence of this method of utilizing the straight line portions of the tube characteristics, the current received at the far end of the line does not vary between zero and finite value, but between two finite values. This electrical bias is exactly matched in the light valve by a mechanical bias of the jaws of the valve opening.

Fig. 12 shows diagrammatically the form of the band pass filters used for separating the picture and synchronizing channels, together with the transmission characteristics of the filters. The synchronizing channel filter transmits a narrow band in the neighborhood of 400 c. p. s., the picture channel filter a band between 600 and 2,500 c. p. s.

In addition to the main circuits which have been discussed, arrangements are made for starting the two ends simultaneously and for the transmission of signals. These functions are performed by the interruption of the picture current working through appropriate detectors and relays. Testing circuits are also provided for adjusting the various elements without the use of the actual transmission line.

The Transmission Line

In view of the fact already emphasized, that the currents used in picture transmission are caused to be similar both as to frequency and amplitude to those used in speech transmission, it follows that no important changes in the transmission characteristics of the telephone line are called for. With regard to the frequency range of the alternating currents which must be transmitted and also the permissible line attenuation, the transmission of pictures is less exacting on the telephone line than is speech transmission. In certain other respects, however, the requirements for picture transmission are more severe. For speech, the fundamental requirement is the intelligibility of the result, which may be preserved even though the transmission varies somewhat during a conversation. In the case of picture transmission, variations in the transmission loss of the line, or noise appearing even for a brief instant during the several minutes required for transmission are all recorded and presented to view as blemishes in the finished picture. Picture transmission circuits must, therefore, be carefully designed and operated so as to reduce the possibility of such disturbances. In transmitting pictures over telephone lines, it is also necessary to guard against certain other effects, including transient

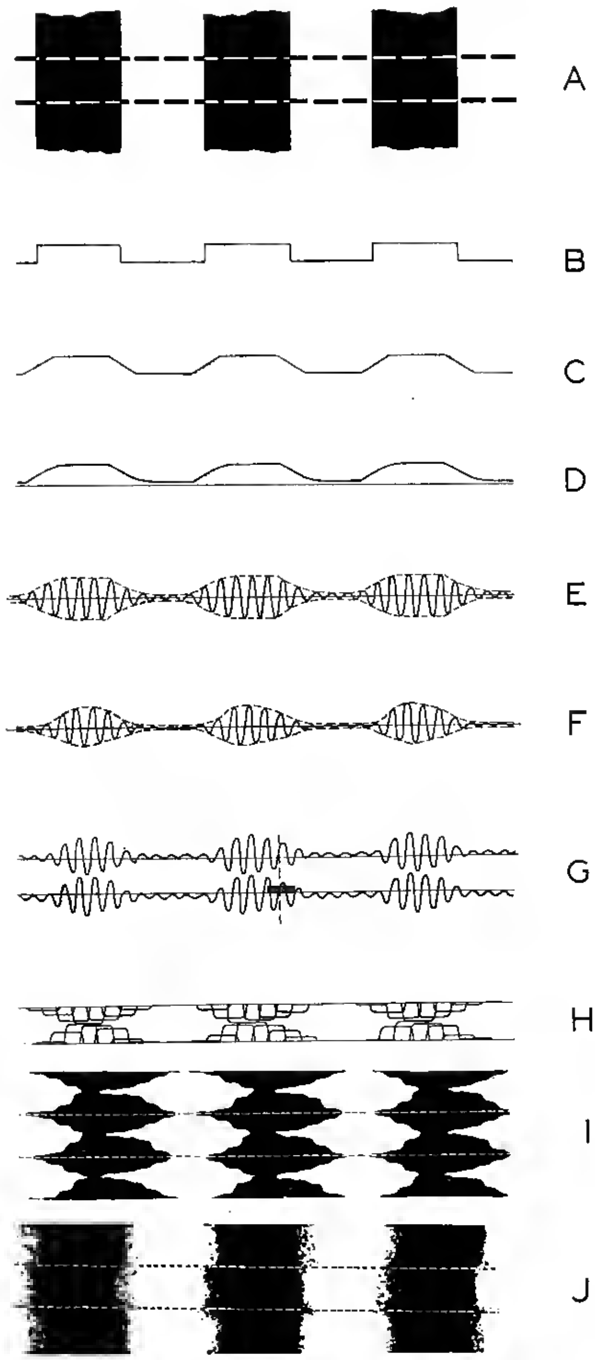

Fig. 13—Diagram illustrating performance of system

effects and "echoes" caused by reflections from impedance irregularities. A high degree of balance between the lines and their balancing networks at repeater points is also required. These conditions can be satisfactorily met on wire telephone lines. Radio communication channels are inherently less stable and less free from interference, and special means to overcome their defects are required in order to secure high-grade pictures.

Characteristics of Received Pictures

All electrically transmitted pictures have, as a result of the processes of scanning at the sending and receiving ends, a certain amount of structure, on the fineness and character of which depends the detail rendering of the result.

The origin and nature of the microscopic structure characteristic of pictures transmitted by the present process is illustrated by the diagrammatic presentation of Fig. 13, which may serve at the same time to give a review of the whole process. We will assume that the original picture consists of a test object of alternating opaque and transparent lines. Such a set of lines is shown at A. The lines are assumed to be moving from left to right across the spot of light falling on the film. The width of the spot of light (corresponding to the pitch of the screw) is represented by the pair of dashed lines. If the spot of light were infinitely narrow in the direction of motion of the picture film, the photoelectric current would be represented in magnitude in the manner shown at B. Actually the spot must have a finite length, so that the transitions between the maximum and minimum values of current are represented by diagonal lines as shown at C. Due to the unavoidable reactances in the amplifying system, there is introduced a certain rounding off of the signal so that the variation of potential impressed on the modulator tube follows somewhat the course shown at D. The alternating current introduced by the vacuum tube oscillator is, then, given the characteristics shown at E, the envelope being a close copy of D. Passing out to the transmission line, the fact that the band of frequencies transmitted by a telephone line is limited in extent results in a certain further rounding off of the envelope of the picture current as shown in F. The ribbon of the light valve when traversed by the alternating current from the line performs oscillations to either side of the center of the aperture, consequently opening first one side of the aperture and then the other. The two curves of sketch G represent the excursions of the light valve ribbon, with time, past the

Fig. 14—Example of electrically transmitted news picture—variable width line system—President and Mrs. Coolidge

edges of the aperture, which latter are indicated by parallel straight lines. Owing to the fact that the light valve aperture must have a finite length in the direction of rotation of the cylinder (indicated by the small rectangle in the center of the sketch), there is a certain overlapping of the light pulses on the film. (This is, in fact, necessary for the production of solid blacks.) These are indicated diagrammatically at *H*. In sketch I are shown, from an actual photomicrograph, the variations in the image of the light valve as traced out on the moving photographic film. Here the dashed lines represent the limits of the image as formed by one rotation of the receiving cylinder. It will be noted that the images due to the opening of the light valve in each direction form a double beaded line. These double lines are juxtaposed, so that the right hand image due to one rotation of the cylinder backs up against the left hand image due to the next rotation, thus forming on the film a series of approximately symmetrical lines of variable width. These are exhibited clearly in the enlarged section of a picture, Fig. 5. It will be understood that for purposes of illustration, the grating used as the test object in the preceding discussion has been represented as traversing the spot of light at the sending end at such a high speed that the final picture is close to the limit of the resolving power of the system. Thus the photomicrograph shown in I must be viewed from a considerable distance in order that its difference in structure from the original object *A* will disappear. A practical problem in the design of picture transmission apparatus is to so choose the speed of rotation of the cylinder with reference to the losses in resolving power incident to transmission that definition is substantially the same along and across the constituent picture lines.

There are, in general, two methods by which a transmitted picture may be received. One of these is to form an image of the light valve aperture on the sensitive photographic surface. When this is done, in the manner described in connection with Fig. 13 the picture is made up of lines of constant density and varying width. A picture of this sort is shown in Fig. 14. A merit of this kind of picture (when received in negative form) is that if the structure is of suitable size (60 to 65 lines to the inch) it may be used to print directly on zinc and thus make a typographic printing plate similar to the earlier forms of half tone, whereby the loss of time usually incident to copying a picture for reproduction purposes may be avoided. A disadvantage of this form of picture is that it does not lend itself readily to retouching or to change of size in reproduction.

Another method of picture reception is to let the light from the

Fig. 15—Portion of transmitted picture of variable density line type, enlarged

Fig. 16—Variable density line picture—Cleveland high level bridge

Fig. 17—Variable density line picture—Portrait of Michael Faraday

Fig. 18—Variable density line picture—President Coolidge taking the oath of office, March 4, 1925

light valve fall upon the film in a diffused manner through an aperture of fixed length so that lines of constant width (exactly juxtaposed) but of varying density are produced. A photomicrograph of a variable density picture of the opaque line test object previously discussed is shown at *J*, Fig. 13. Prints made from film negatives received in this way, if the structure is chosen fine enough (100 lines to the inch or more) are closely similar in appearance to original photographic prints and may be reproduced through the ordinary half-tone cross-line screen. They may be retouched or subjected to special photographic procedures in any way desired. An enlargement of a portion of a variable density picture is shown in Fig. 15 and examples of complete pictures so received are shown in Figs. 16, 17 and 18.

Electrically transmitted pictures are, in general, suitable for all purposes for which direct photographic prints are used. Such uses include half-tone reproduction for magazines and newspapers, lantern slides, display photographs, etc. Among these uses may be mentioned, as of some interest, the transmission of the three black and white records used for making three-color printing plates. The frontispiece to this article is an example of a three-color photograph transmitted in the form of three black and white records, each corresponding to one of the primary colors, from which printing plates were made at the receiving end.

Some practical details of the procedure followed in the transmission of pictures by the apparatus described may serve to clarify the foregoing description. The picture to be transmitted is usually provided in the form of a negative, which is apt to be on glass and of any one of a number of sizes. From this a positive is made on a celluloid film of dimensions 5″ x 7″, which is then placed in the cylindrical film-holding frame at the sending end. Simultaneously an unexposed film is placed on the receiving end. Adjustments of current values for "light" and "dark" conditions are then made, over the line; after which the two cylinders are simultaneously started by a signal from one end. The time of transmission of a 5″ x 7″ picture is, for a 100 line to the inch picture, about seven minutes. This time is a relatively small part of the total time required from the taking of the picture until it is delivered in the form of a print. Most of this total time is used in the purely photographic operations. When these are reduced to a minimum by using the negative and the sending end positive while still wet, and making the prints in a projection camera without waiting for the received negative to dry, the overall time is of the order of three-quarters of an hour.

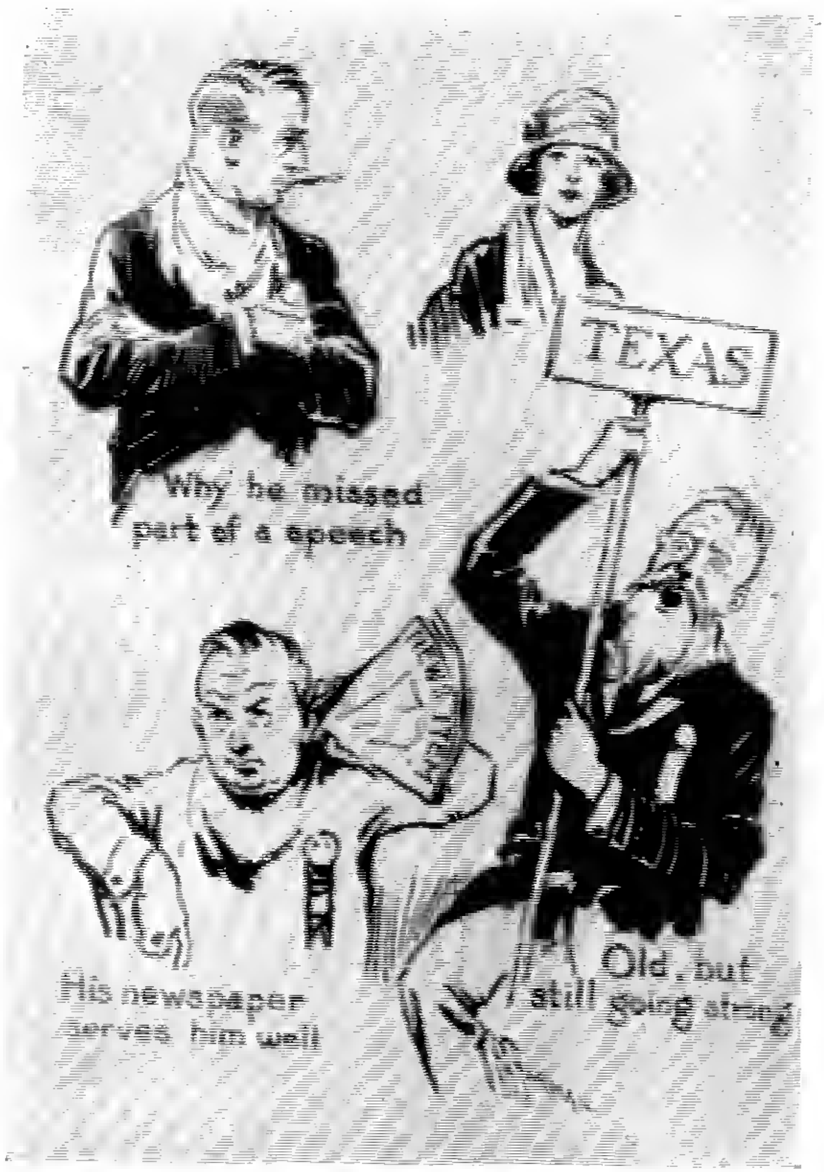

Fig. 19—Electrical transmission of cartoon

Fields of Usefulness

The fields in which electrically transmitted pictures may be of greatest service are those in which it is desired to transmit information which can only be conveyed effectively, or at all, by an appeal to vision. Illustrations of cases where an adequate verbal description is almost impossible, are portraits, as, for instance, of criminals

Fig. 20—Electrically transmitted fingerprint

or missing individuals; drawings, such as details of mechanical parts, weather maps, military maps, or other representations of transient conditions.

The value of electrically transmitted pictures in connection with police work has been recognized from the earliest days of experiments in the transmission of pictures. Besides the transmission of portraits of wanted individuals to distant points, there is now possible the transmission of finger prints. Some of the possibilities of the latter were demonstrated over the New York-Chicago picture sending circuit at the time of the Democratic Convention, July, 1924. The Police Department of New York selected the fingerprint of a criminal whose complete identification data were on file in the Police Department in Chicago. This single fingerprint, together with a code description of the prints of all the fingers, was

transmitted to Chicago and identified by the Chicago experts almost instantly. This method of identification will be, it is thought, of value in those cases where difficulty is now experienced in holding a suspect long enough for identification to be completed. Fig. 20 shows a transmitted fingerprint.

The fact that an electrically transmitted picture is a faithful copy of the original, offers a field of usefulness in connection with the

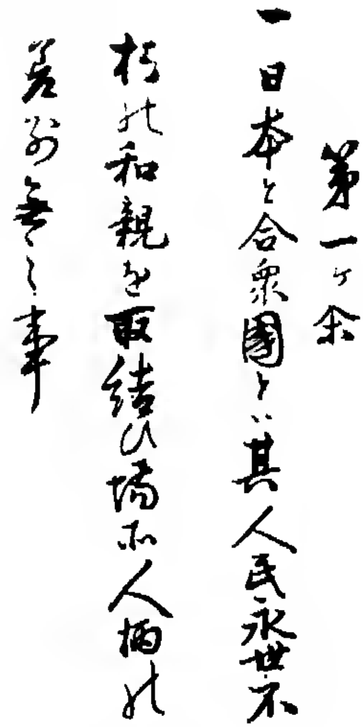

Fig. 21—Transmission of autograph material—First section of Japanese-American Treaty of 1853

transmission of original messages or documents in which the exact form is of significance, such as autographed letters, legal papers, signatures, etc. It would appear that this method might under certain circumstances save many days of valuable legal time and the accumulation of interest on money held in abeyance. For these reasons, it is thought that bankers, accountants, lawyers, and large real estate dealers will find a service of this kind useful. Fig. 22 illustrates the transmission of handwriting.

Messages in foreign languages, employing alphabets of forms not suited for telegraphic coding, are handled to advantage. Thus, Fig. 21 shows the first section of the original Japanese-American treaty in Japanese script, as transmitted from New York to Chicago.

Advertising material, particularly when in the form of special typography and drawings is often difficult and costly to get to distant publishers in time for certain issues of periodicals and magazines. A wire service promises to be of considerable value for this purpose.

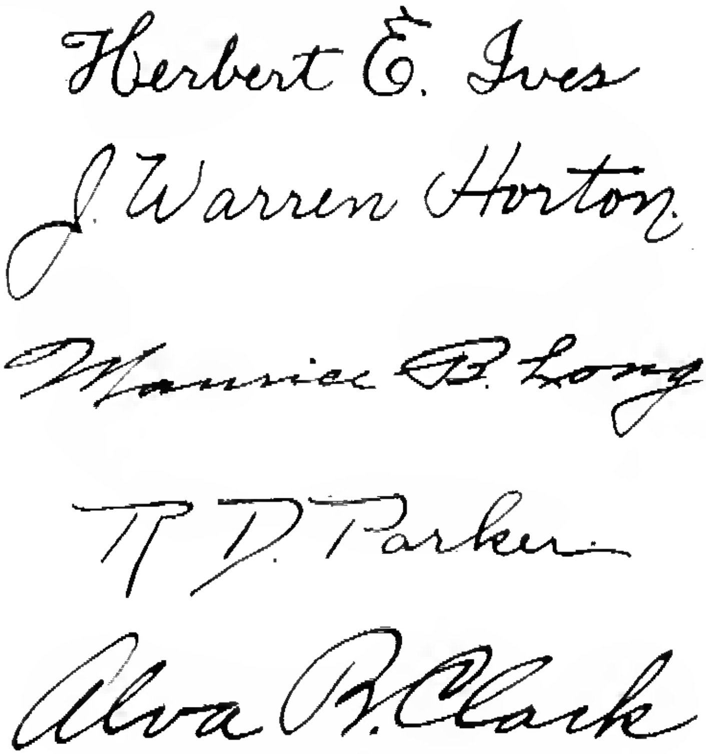

Fig. 22—Transmission of signatures

A very large field for electrically transmitted pictures is, of course, The Press. Their interest in the speedy transportation of pictures has been indicated in the past by the employment of special trains, aeroplanes, and other means for quickly conveying portraits and pictures of special events, to the large news distributing centers. The use of pictures by newspapers seems at present to be growing in

favor, and many are now running daily picture pages as regular features.

Some of the possibilities in this direction were demonstrated by the picture news service furnished to newspapers, especially those in New York and Chicago, during the 1924 Republican and Democratic National Conventions at Cleveland and New York. During these conventions several hundred photographs were transmitted between Cleveland and New York and between New York and Chicago, and copies furnished the Press at the receiving points. Photographs made shortly after the opening sessions, usually about noon, were transmitted to New York and Chicago and reproduced in afternoon papers. A demonstration of picture news service on a still larger scale was furnished on March 4th, 1925, when pictures of the inauguration of President Coolidge were transmitted from Washington simultaneously to New York, Chicago and San Francisco, appearing in the afternoon papers in all three cities. Illustrations of typical news pictures are given in Figs. 14 and 18. The transmission of timely cartoons offers another field for service, Fig. 19.

Other news-distributing agencies can also use electrically transmitted pictures to advantage. Among these are the services which make a specialty of displaying large photographs or half-tone reproductions in store windows and other prominent places. Electrically transmitted pictures of interesting events, about which newspapers have published stories, appear suited to this service, and have already been so used by some of these picture service companies. They may also be used as lantern slides for the display of news events of the day by projection either upon screens in front of newspaper offices or in moving picture theaters.

Miscellaneous commercial uses have been suggested. Photographs of samples or merchandise, of building sites, and of buildings for sale may be mentioned. The quick distribution of moving picture "stills" which is now done by aeroplane is one illustration of what may prove to be a considerable group of commercial photographs for which speedy distribution is of value.